MULTIPHASE EXTRACTION THEORY vs. PRACTICE

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SITE HISTORY:

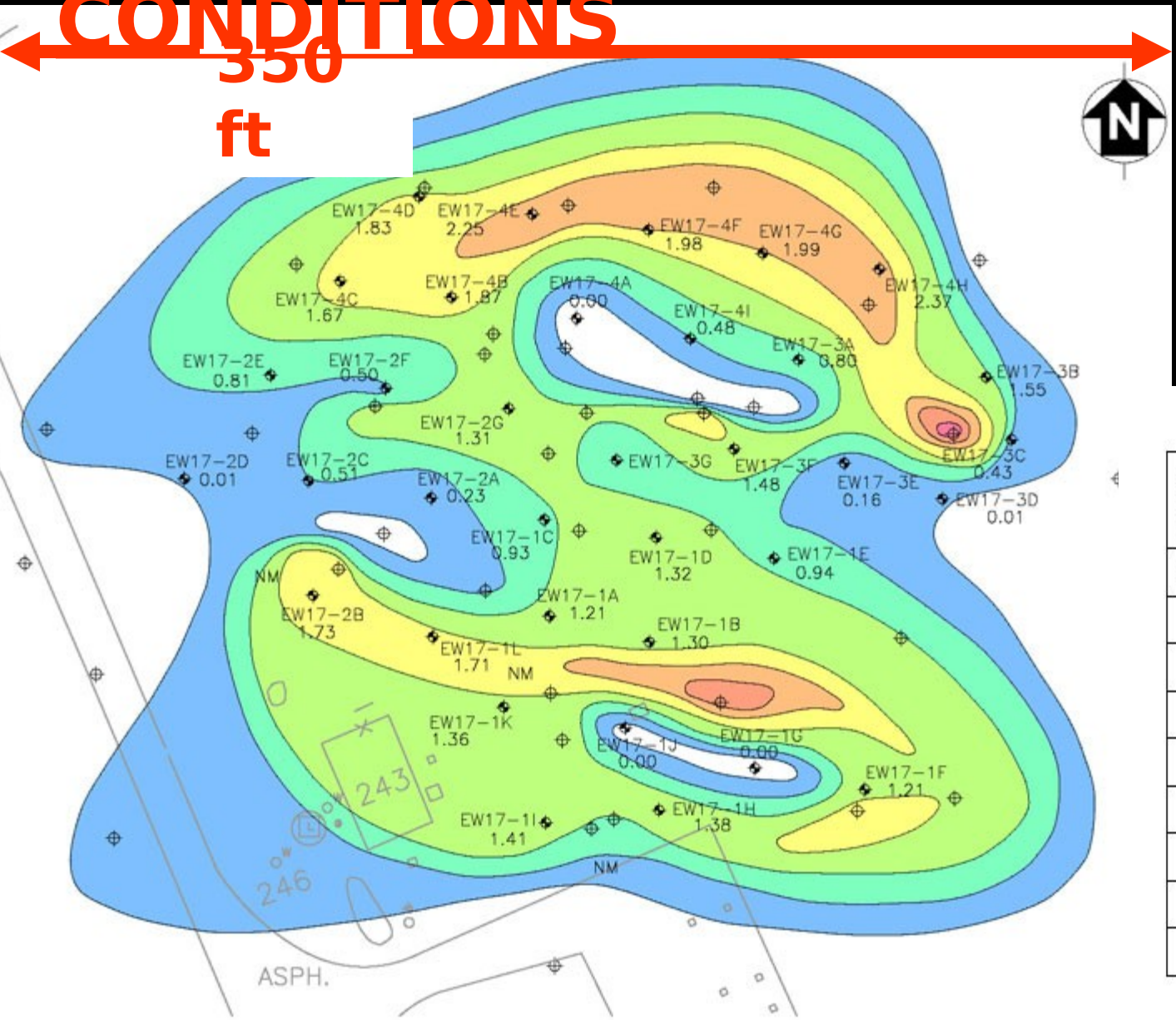
- NAVAL AIR STATION LEMOORE, NEAR FRESNO, CALIFORNIA
- ACTIVE F/A-18 FIGHTER BASE
- JP-5 JET FUEL (KEROSENE) SPILL DISCOVERED IN 1987—UNKNOWN VOLUME
- 100,000 GALLONS RECOVERED FROM AN EXCAVATION IN 1986
- IN 1994, BATTELLE OPERATED A STEAM INJECTION/VAPOR EXTRACTION SYSTEM THAT REMOVED 80,000 GALLONS—ALL FREE PRODUCT APPEARED TO HAVE BEEN REMOVED
- IN 1998, AS PART OF SITE CLOSEOUT ACTIVITIES, 3 FEET OF PRODUCT WAS FOUND THROUGHOUT THE SITE

SITE GEOLOGY

- **WATER TABLE AT 10 – 15 Ft BGS**
- **SANDY SILT CHANNELS INTERBEDDED WITH CLAY**
- **FINING UPWARDS**
- **<u>NOT</u> A DRINKING WATER AQUIFER—ONLY HAVE TO REMOVE FREE PRODUCT—DON’T HAVE TO TREAT DISSOLVED-PHASE IN GROUNDWATER**

INITIAL FREE PRODUCT CONDITIONS

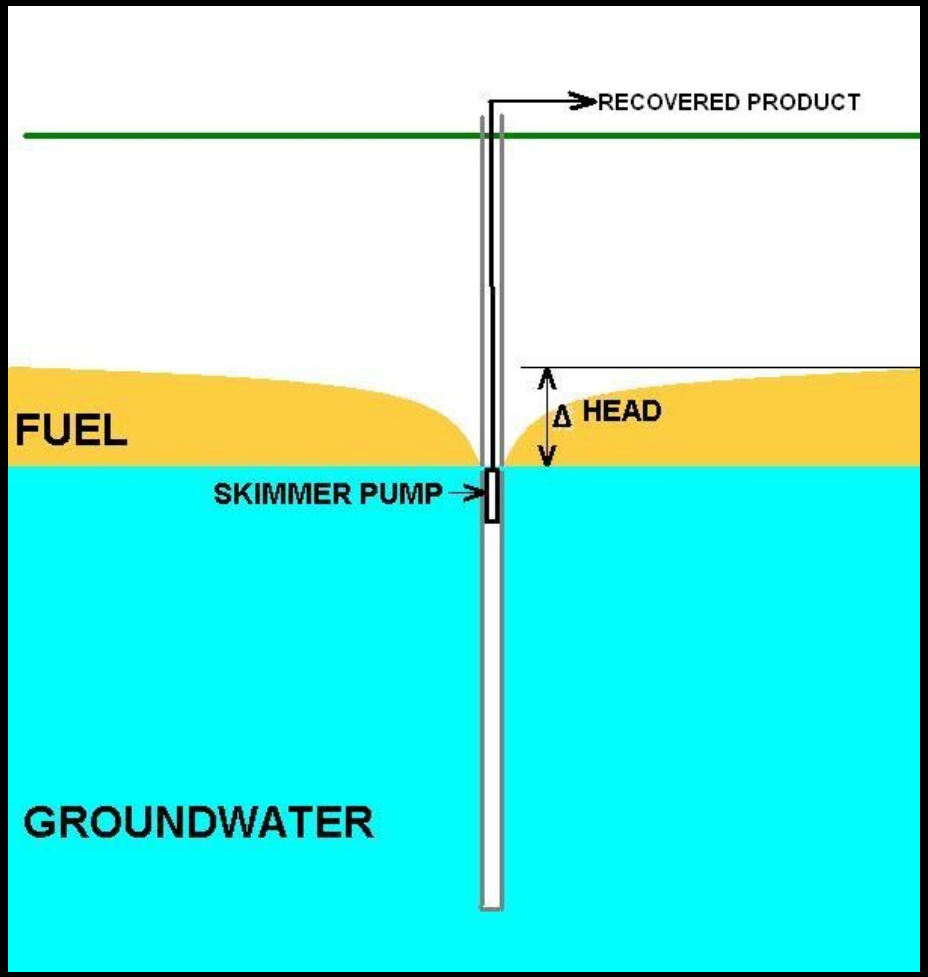
350 ft



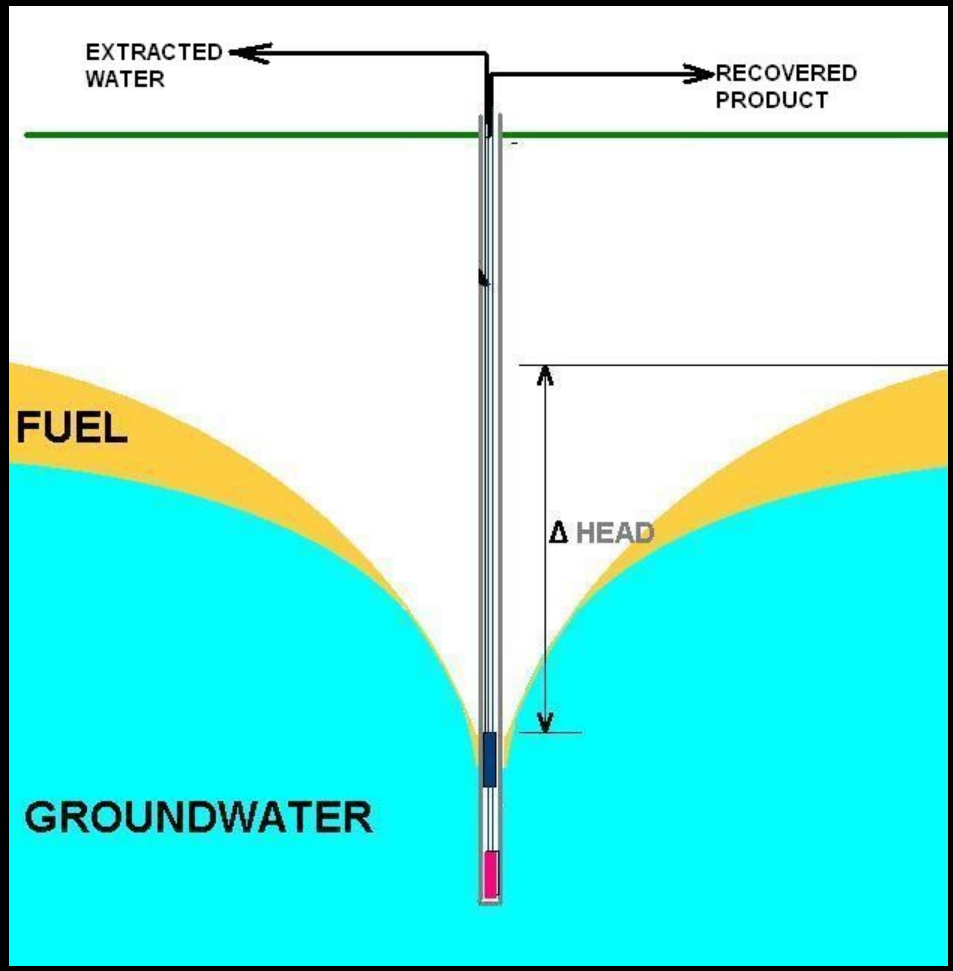
AREAL EXTENT OF FREE PRODUCT IS APPOXIMATELY 2 ACRES

APPARENT FREE PRODUCT THICKNESS (FEET)	CONTOUR INTERVAL
DETECT TO 0.49	
0.5 TO 0.99	
1.00 TO 1.49	
1.50 TO 1.99	
2.00 TO 2.49	
2.50 TO 2.99	
3.00 TO 3.49	
3.50 TO 3.99	
> 4.00	

CONVENTIONAL PRODUCT RECOVERY SYSTEMS

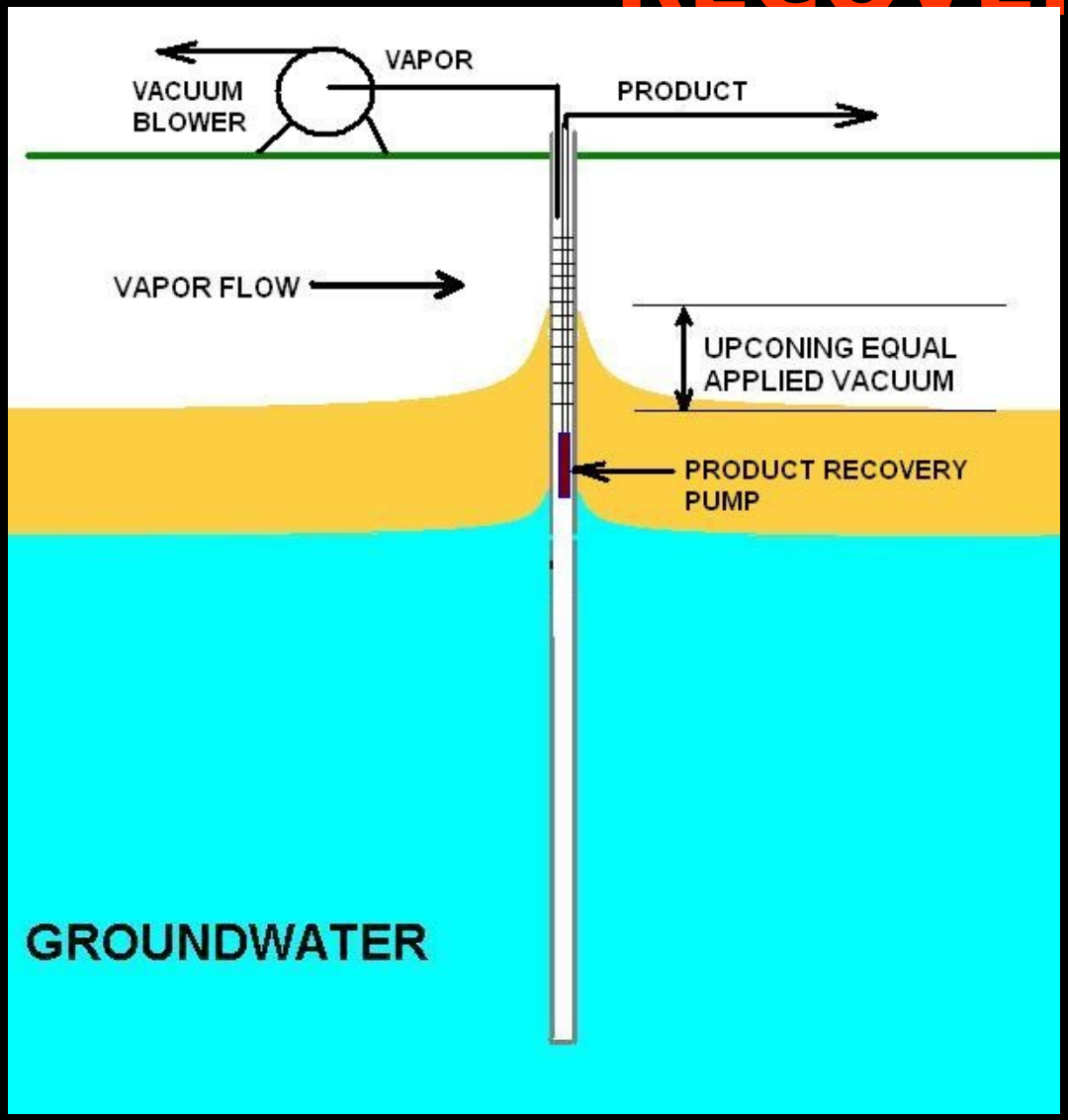


SKIMMER PUMP



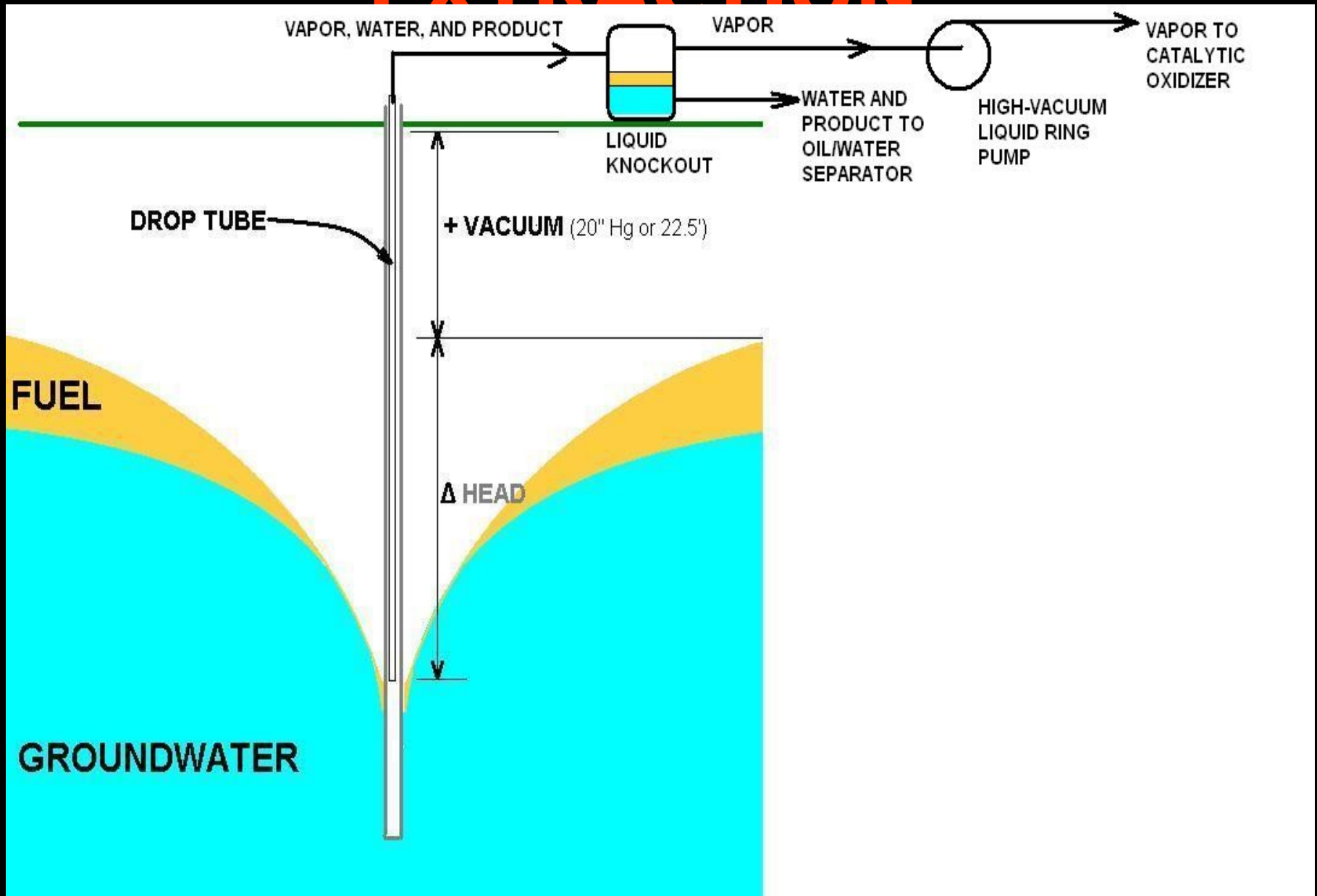
TWO PUMP SYSTEM

VACUUM ENHANCED RECOVERY



- VACUUM REMOVES VADOSE ZONE CONTAMINATION
- INCREASES PRODUCT RECOVERY RATE IN TIGHT SOILS
- HOWEVER, IF PRODUCT RECOVERY PUMPING RATE DOES NOT EXCEED VACUUM, PRODUCT MAY UPCONE
- GOOD FOR BULK FUEL RECOVERY, DIFFICULT WHEN FUEL THICKNESS IS < 1 FOOT

MULTI-PHASE EXTRACTION



BENEFITS OF MPE:

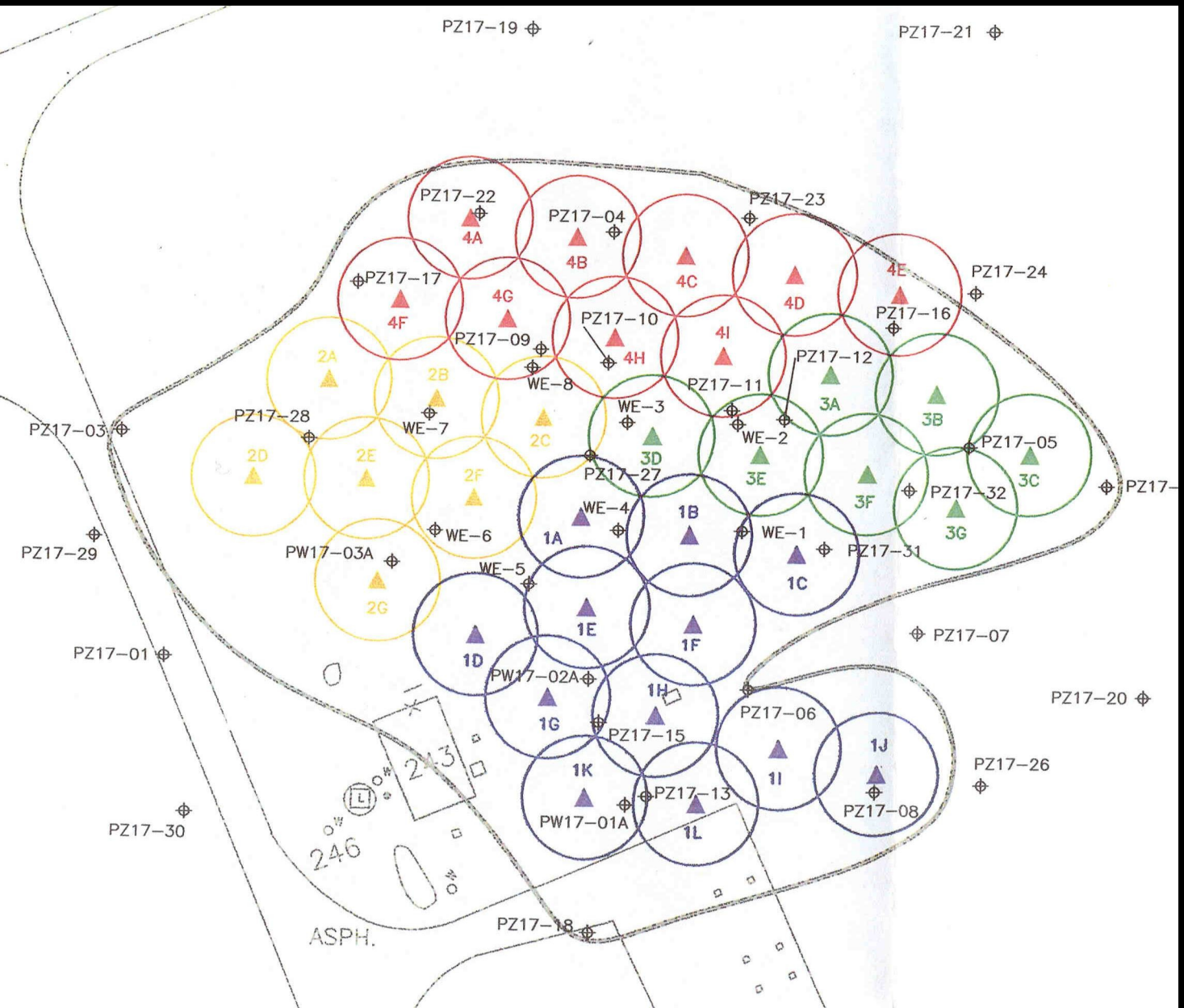
- **INCREASED DRIVING FORCE (I.e drawdown + vacuum) INCREASES PRODUCT RECOVERY RATES (from gallons per day to gallons per minute at NAS Lemoore) = FASTER REMEDIATION**
- **VACUUM EXTRACTION REMOVES CONTAMINATED VAPORS, REMEDIATING VADOSE ZONE SOILS**
- **REMOVES RESIDUAL LNAPL (not just mobile NAPL)**
- **JUMPS STARTS BIOREMEDIATION BY BIO-VENTING VADOSE ZONE SOILS**
- **PROVIDE HYDRAULIC CONTROL OF LNAPL**

DRAWBACKS OF MPE:

- **INSTEAD OF ONLY RECOVERING FUEL, CONTAMINATED GROUNDWATER AND CONTAMINATED VAPOR MUST BE TREATED**

Behold the POWER of MPE !!

EXTRACTION WELL LAYOUT

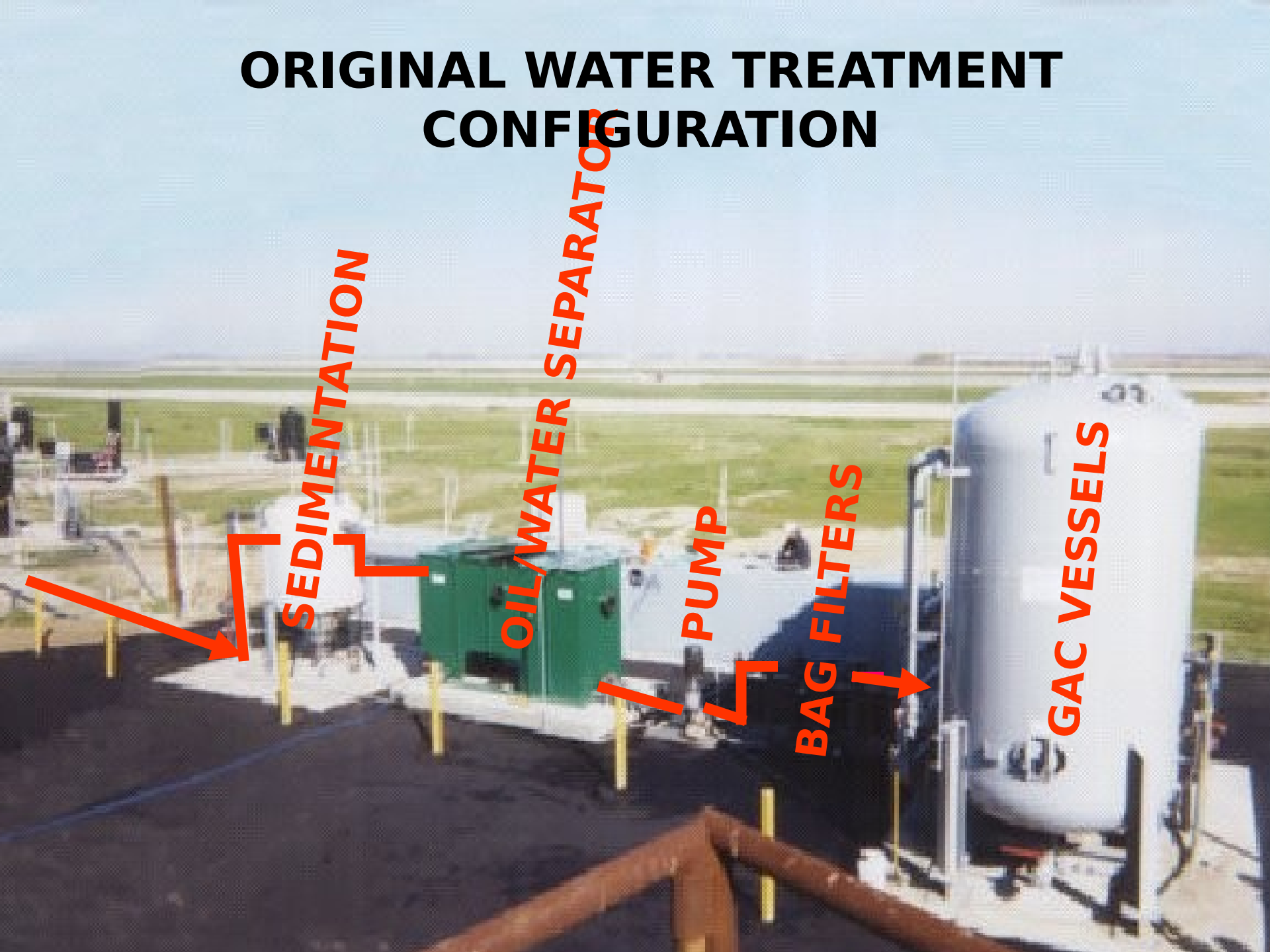


- 35 WELLS SPACED ON 30-ft CENTERS
- PIPED TO FOUR EXTRACTION UNITS
- EACH UNIT HAS A 60-hp LIQUID RING PUMP THAT PROVIDES 100 SCFM @26” Hg
- TYPICAL YIELD IS 0.5 gpm PER WELL

TYPICAL EXTRACTION WELL

EXTRACTION WELL MANIFOLD

ORIGINAL WATER TREATMENT CONFIGURATION

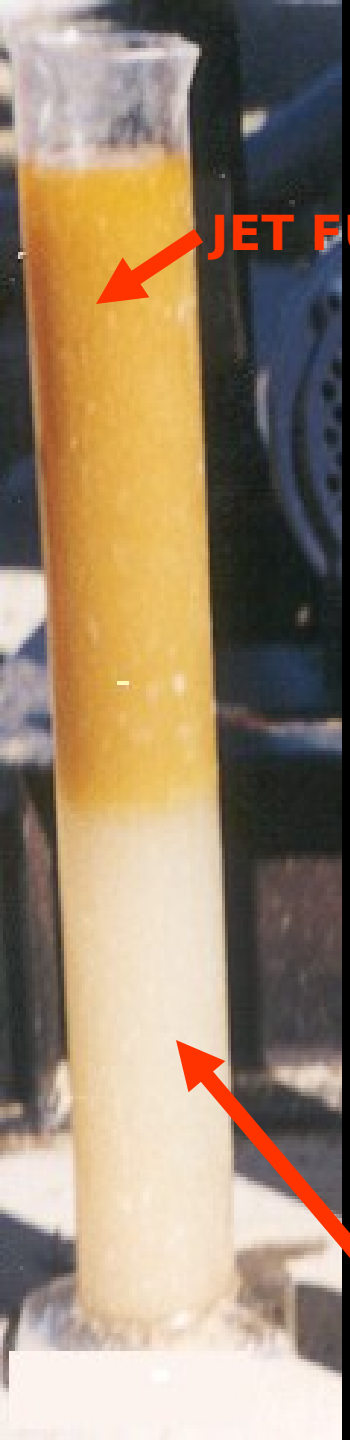


SYSTEM EFFLUENT REQUIREMENTS

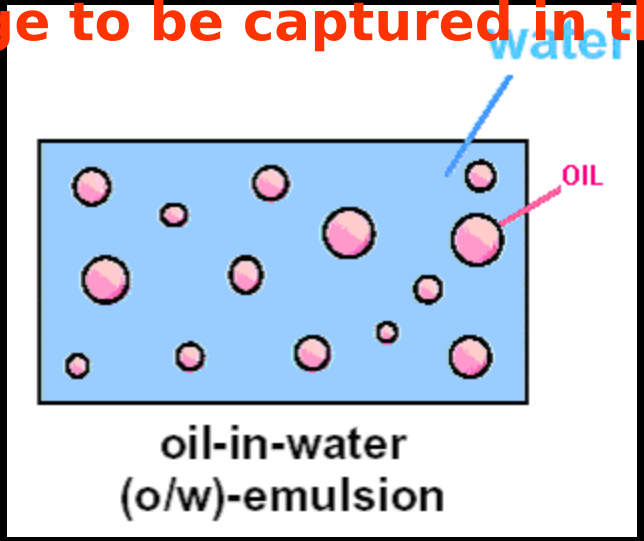
- NO NEARBY SURFACE WATER FOR NPDES DISCHARGE
- NO POTW

- SYSTEM EFFLUENT IS DISCHARGED TO A LEACH FIELD 1,000 FEET SOUTH OF THE SYSTEM
- EFFLUENT REQUIREMENTS ARE:
  < 50 µg/L TPH AND < 0.5 µg/L BTEX

BUT I THOUGHT OIL AND WATER DON'T MIX?



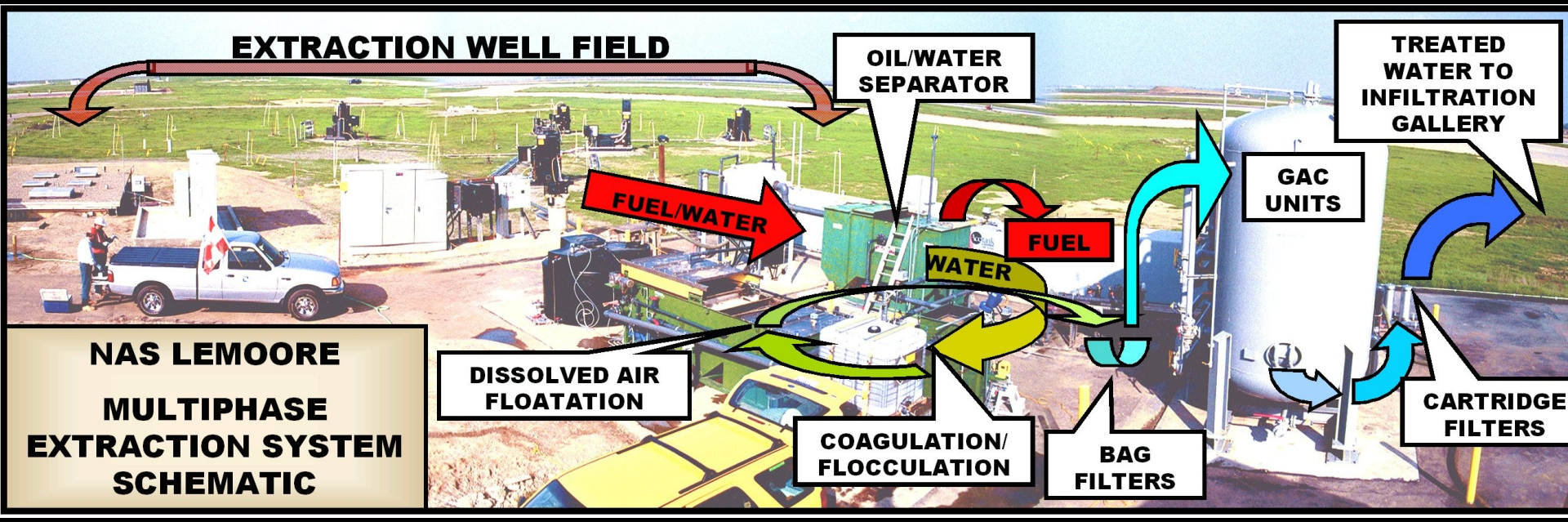
- Emulsions are formed by mechanical agitation (shearing) or chemical means (such as surfactants)
- Emulsions are typically smaller than 10 microns
- Emulsions can be stabilized by particulates (such as clay)
- Emulsions are too large to be captured in the pores of GAC



EMULSION REMOVAL METHODS

- DISSOLVED AIR FLOATATION
- COAGULATION/FLOCCULATION
- CLAY ADSORPTION
- MEMBRANE FILTRATION
- HEAT
- PLASTIC ADSORPTION

NEW CONFIGURATION



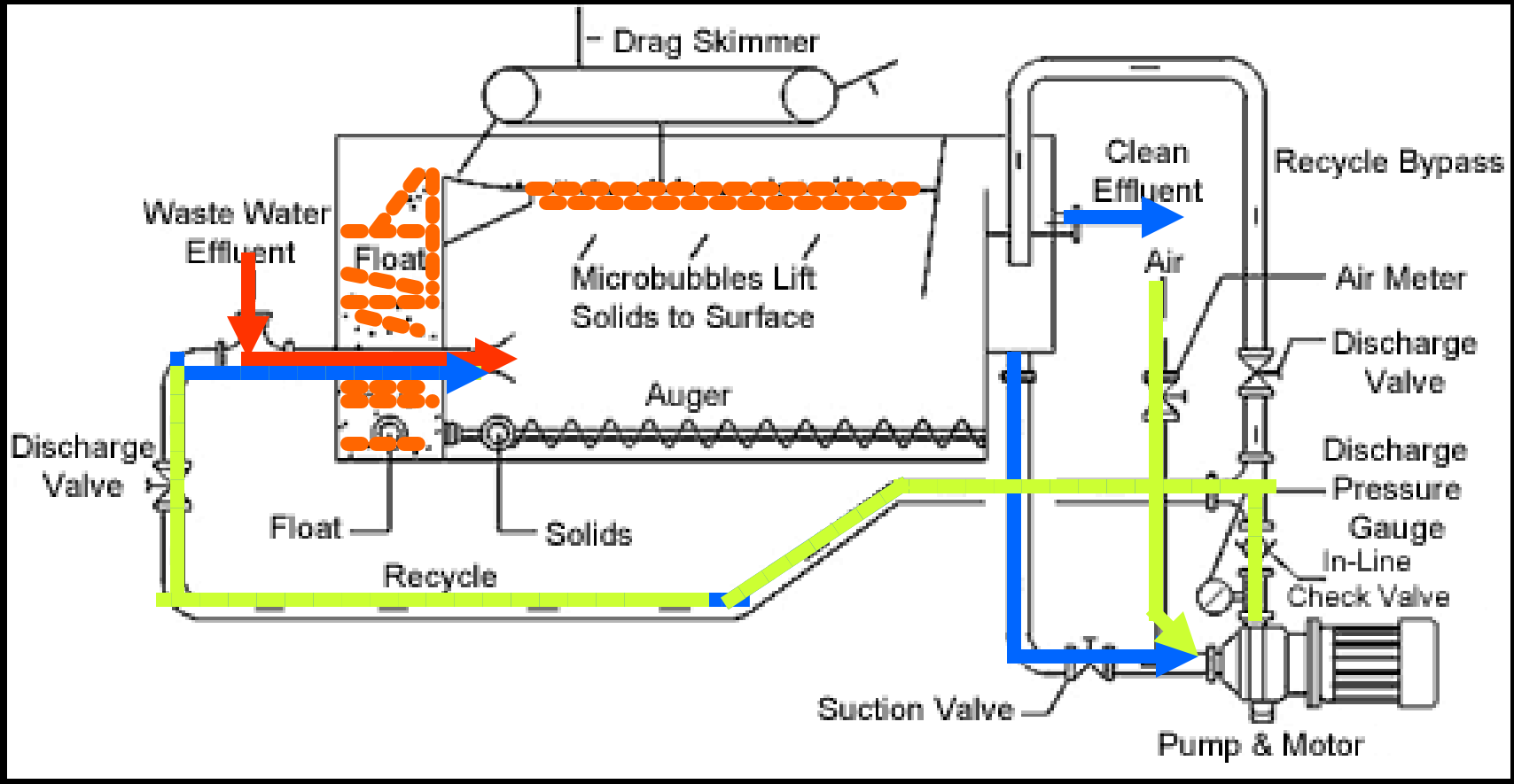
NEW SYSTEM MAXIMUM FLOWRATE IS 30 gpm

TYPICAL FLOWRATE IS 15 gpm

HOW DISSOLVED AIR FLOATATION WORKS:

- COAGULANT REDUCES THE CHARGE BETWEEN EMULSIFIED PARTICLES
- FLOCCULANT AGGLOMERATES COAGULATED PARTICLES INTO LARGER FLOC
- DISSOLVED AIR RELEASES MICROSCOPIC BUBBLES (50-micron) THAT ATTACH TO THE FLOC AND CARRY IT TO THE SURFACE
- SKIMMER REMOVES “FLOAT”

DISSOLVED AIR FLOATATION



OIL/WATER EMULSION

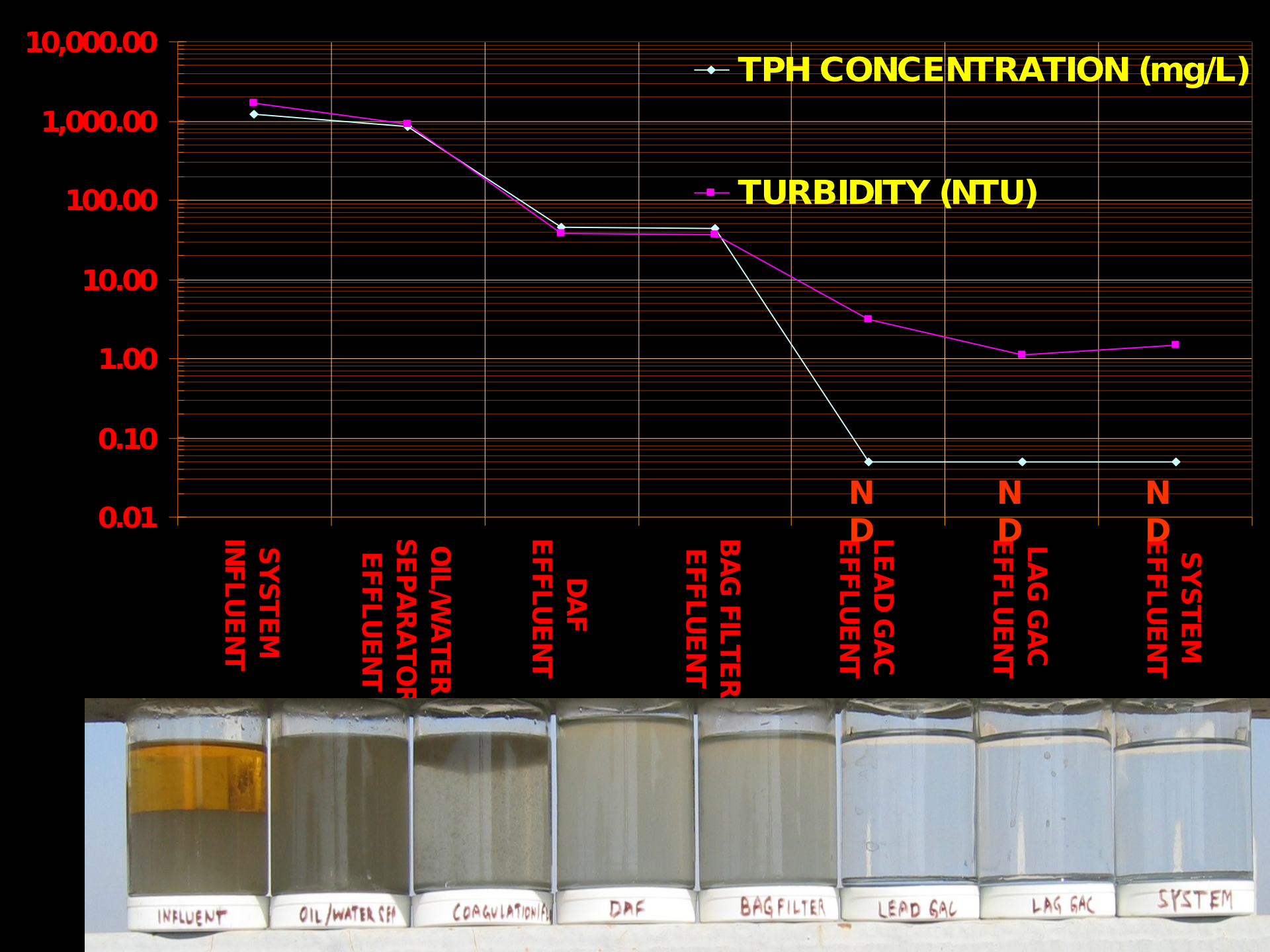
AIR

TREATED WATER

TREATED WATER WITH DISSOLVED AIR

FLOAT

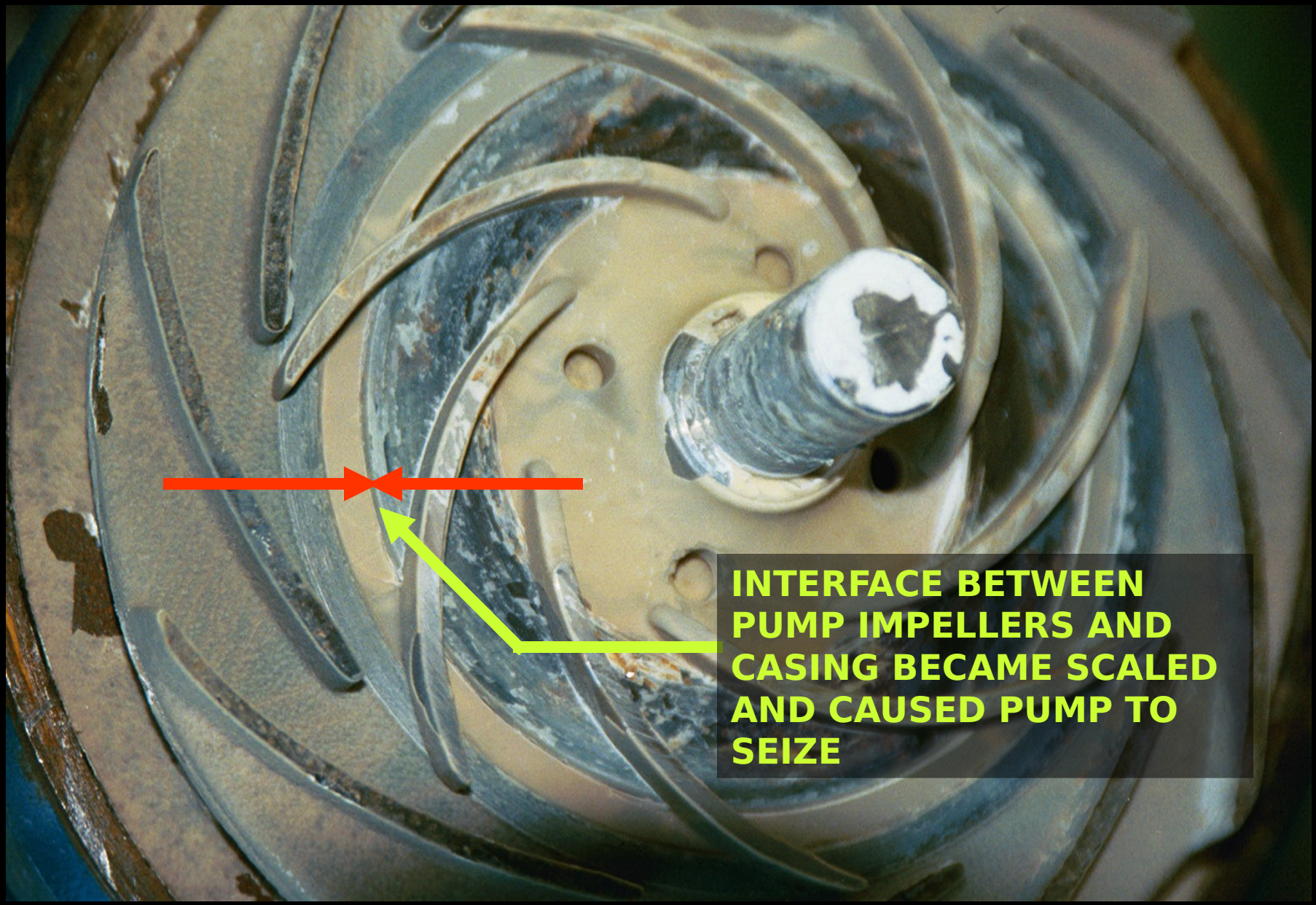
DAF UNIT IN ACTION


10,000.00
1,000.00
100.00
10.00
1.00
0.10
0.01
TPH CONCENTRATION (mg/L)
TURBIDITY (NTU)
ND
ND
ND
SYSTEM INFLUENT
OIL/WATER SEPARATOR EFFLUENT
DAF EFFLUENT
BAG FILTER EFFLUENT
LEAD GAC EFFLUENT
LAG GAC EFFLUENT
SYSTEM EFFLUENT
INFLUENT
OIL/WATER SEP
COAGULATION/FL
DAF
BAG FILTER
LEAD GAC
LAG GAC
SYSTEM

PROBLEMS WITH DAF:

- GENERATES FLOAT (ABOUT 2 TO 3 PERCENT OF WATER TREATED)
- FRAGILE FLOC CAN EASILY SHEAR AND PASS THROUGH THE DAF UNIT
- HIGH TDS CAN FOUL PUMPS/DIFFUSERS

SCALE FORMATION ON THE DAF PUMP



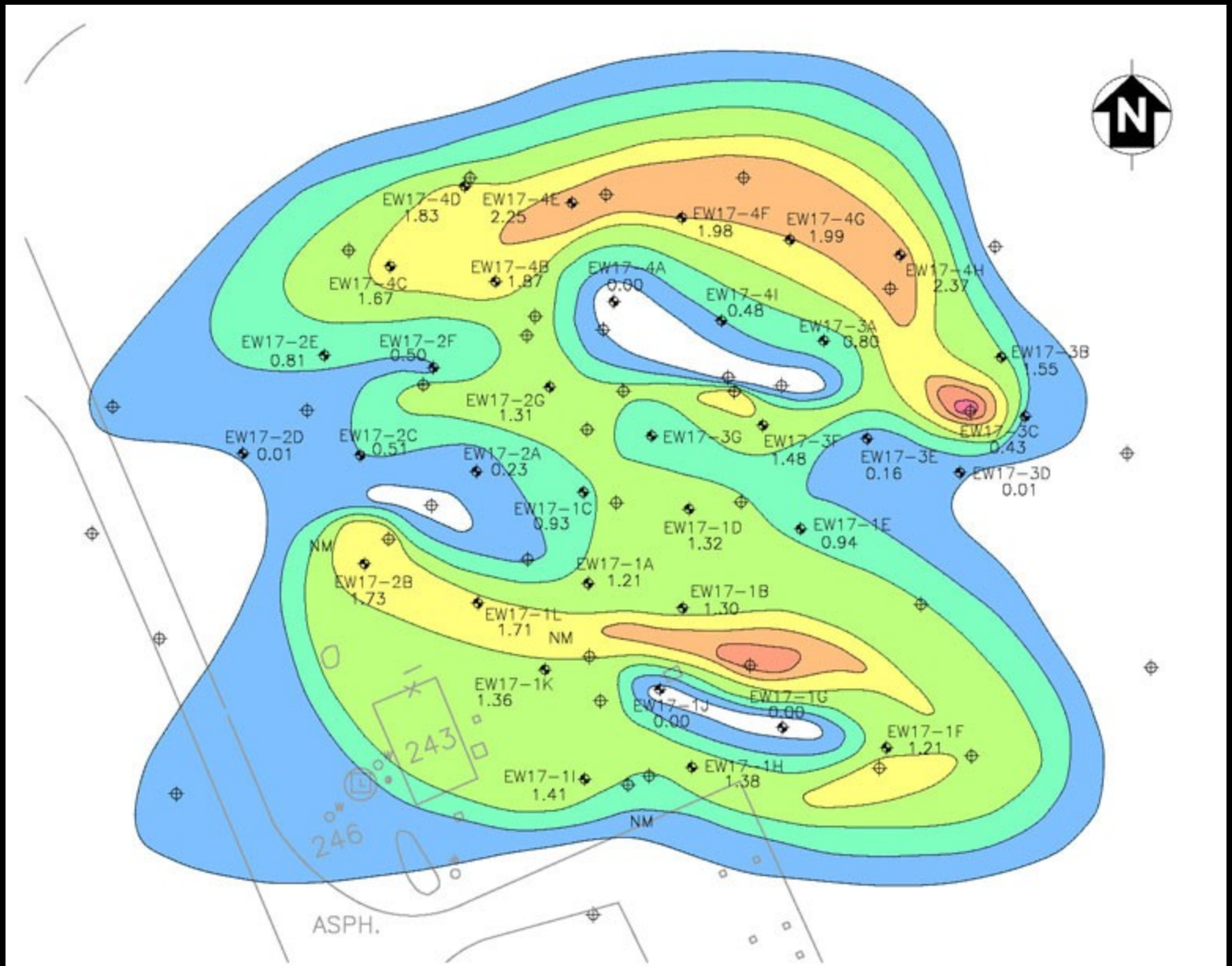
BIOLOGICAL GROWTH IN JET FUEL

- SEVERAL TYPES OF BACTERIA AND FUNGUS LIVE AT THE OIL/WATER INTERFACE
- GROWTH CLOGS OIL/WATER SEPARATOR COALESCING MEDIA
- CONTAMINATES RECOVERED FUEL —INCREASING DISPOSAL COST

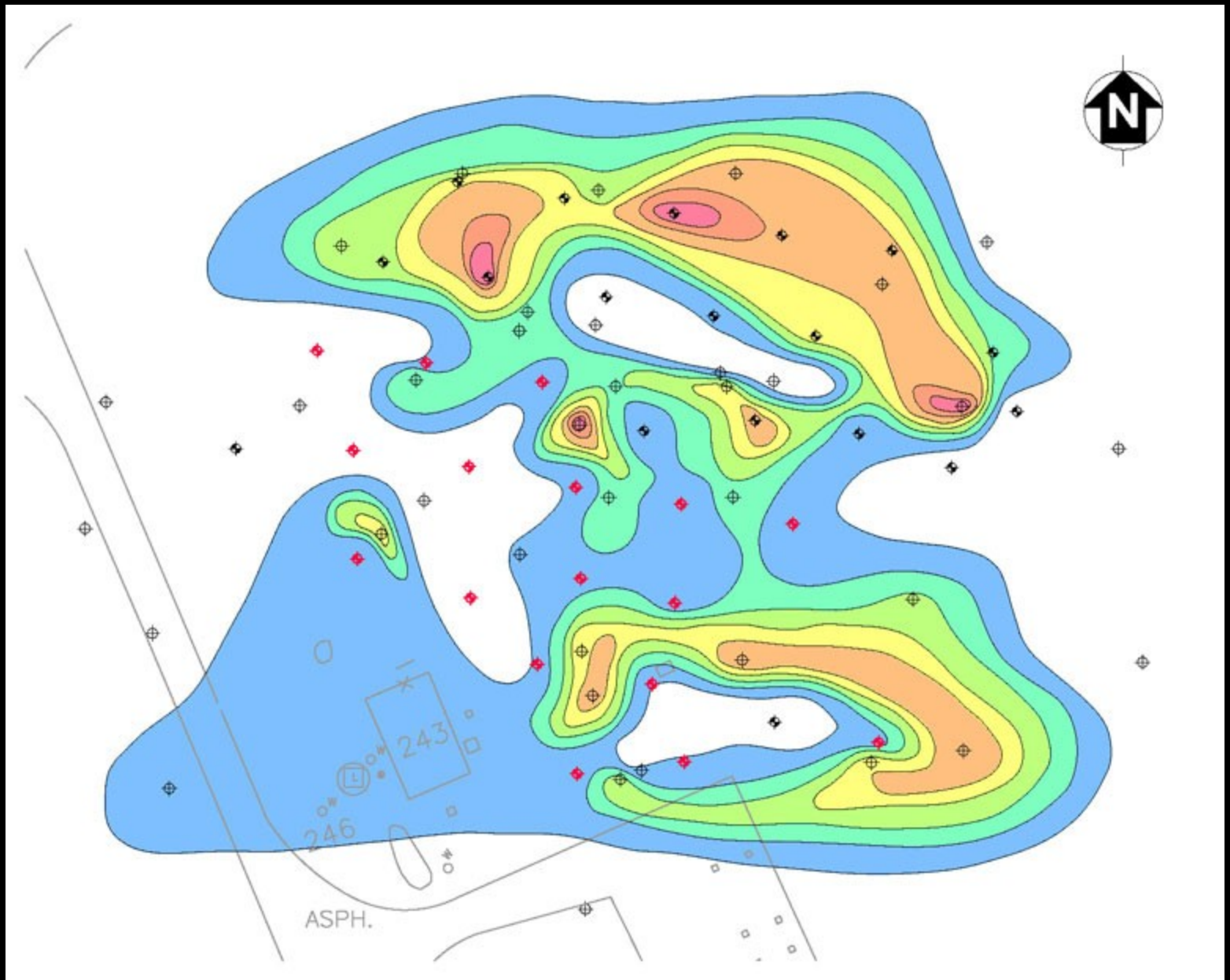
FLOAT GENERATION

- GENERATE 300 GALLONS PER DAY
- STORED IN 21,000-GALLON BAKER TANK
- SEPARATES INTO A FLOAT LAYER, A CLEAR WATER LAYER, AND SLUDGE
- CLEAR WATER IS RE-PROCESSED THROUGH THE SYSTEM, REDUCING VOLUME BY 90 PERCENT

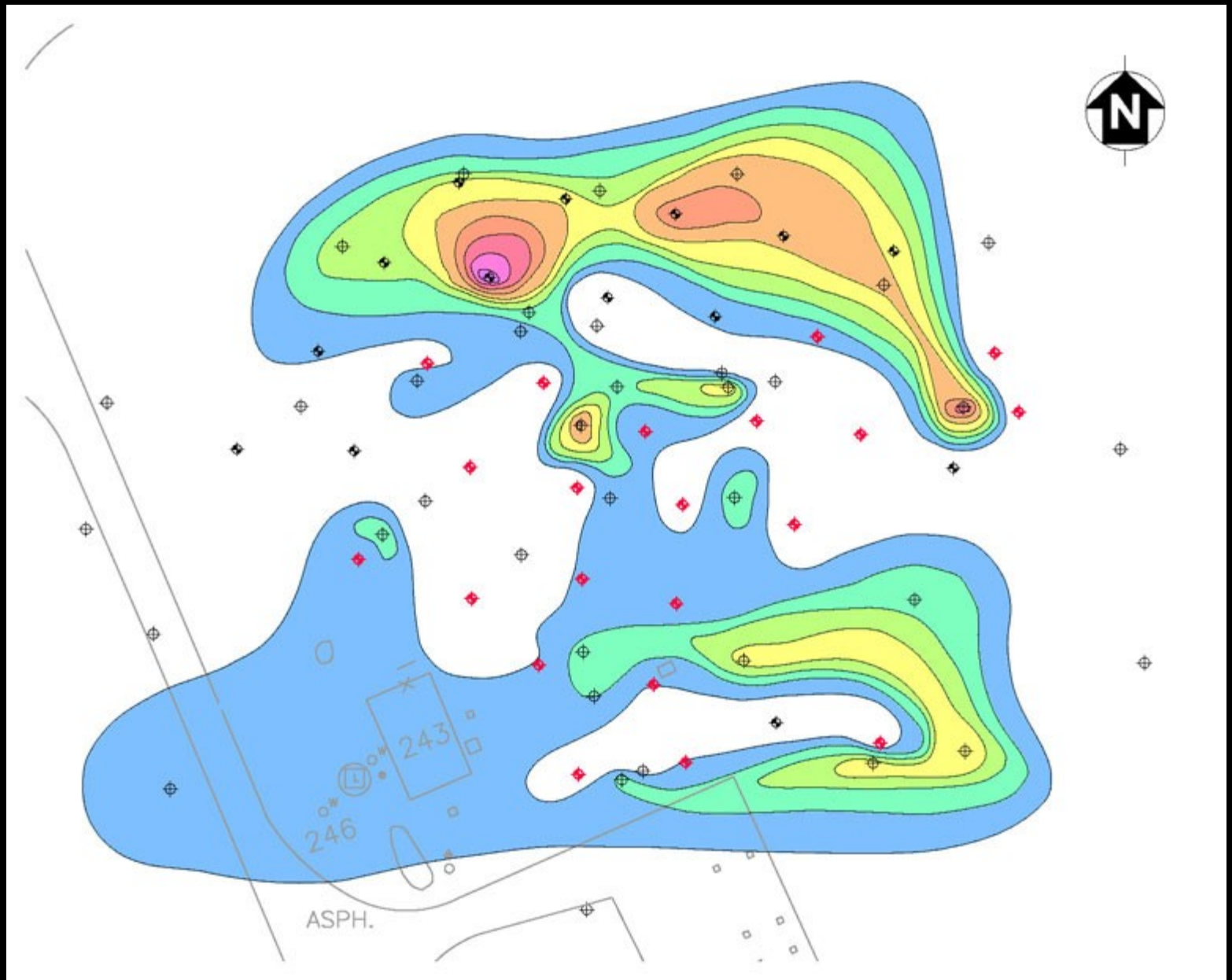
BASELINE CONDITIONS



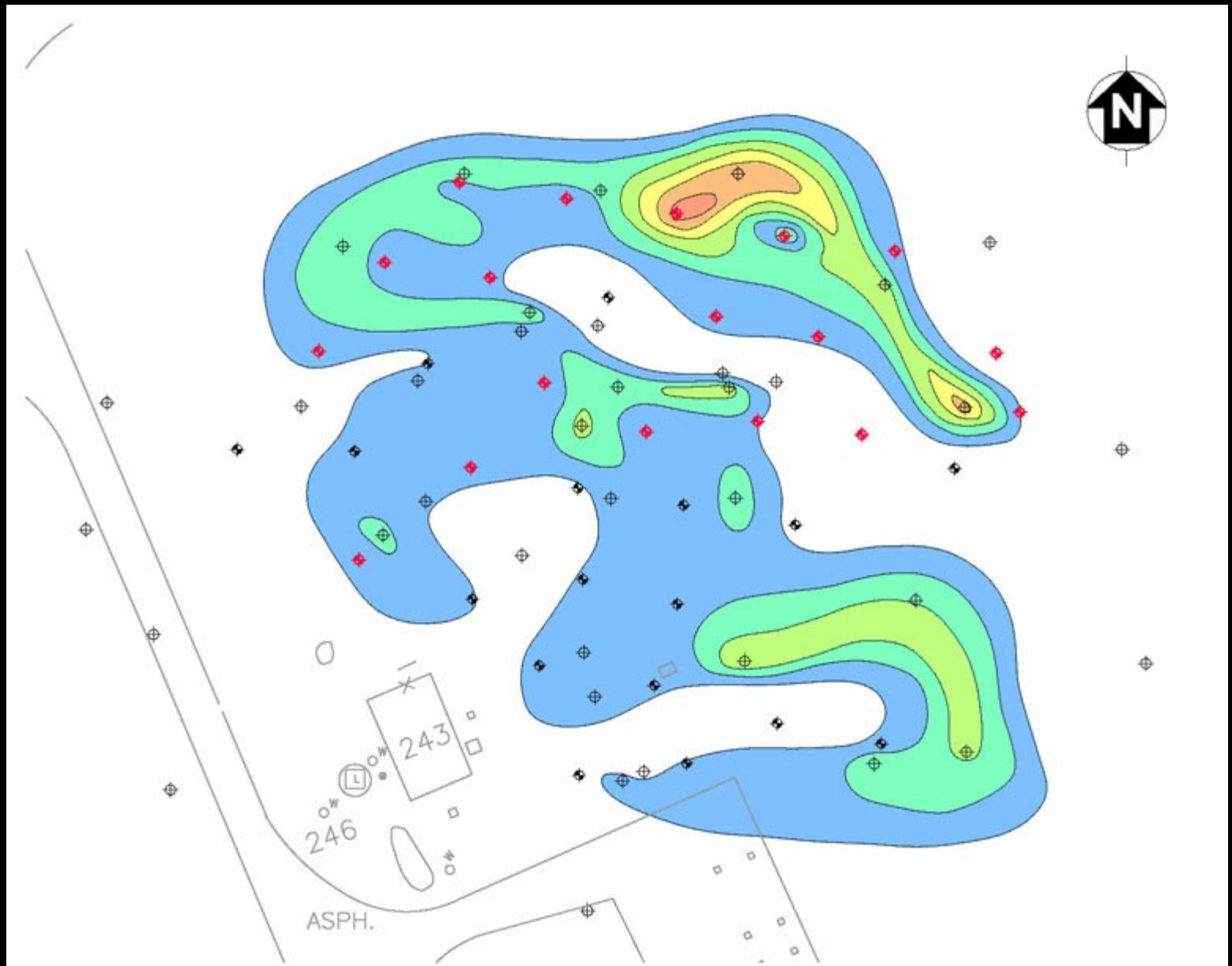
AFTER 2 MONTHS



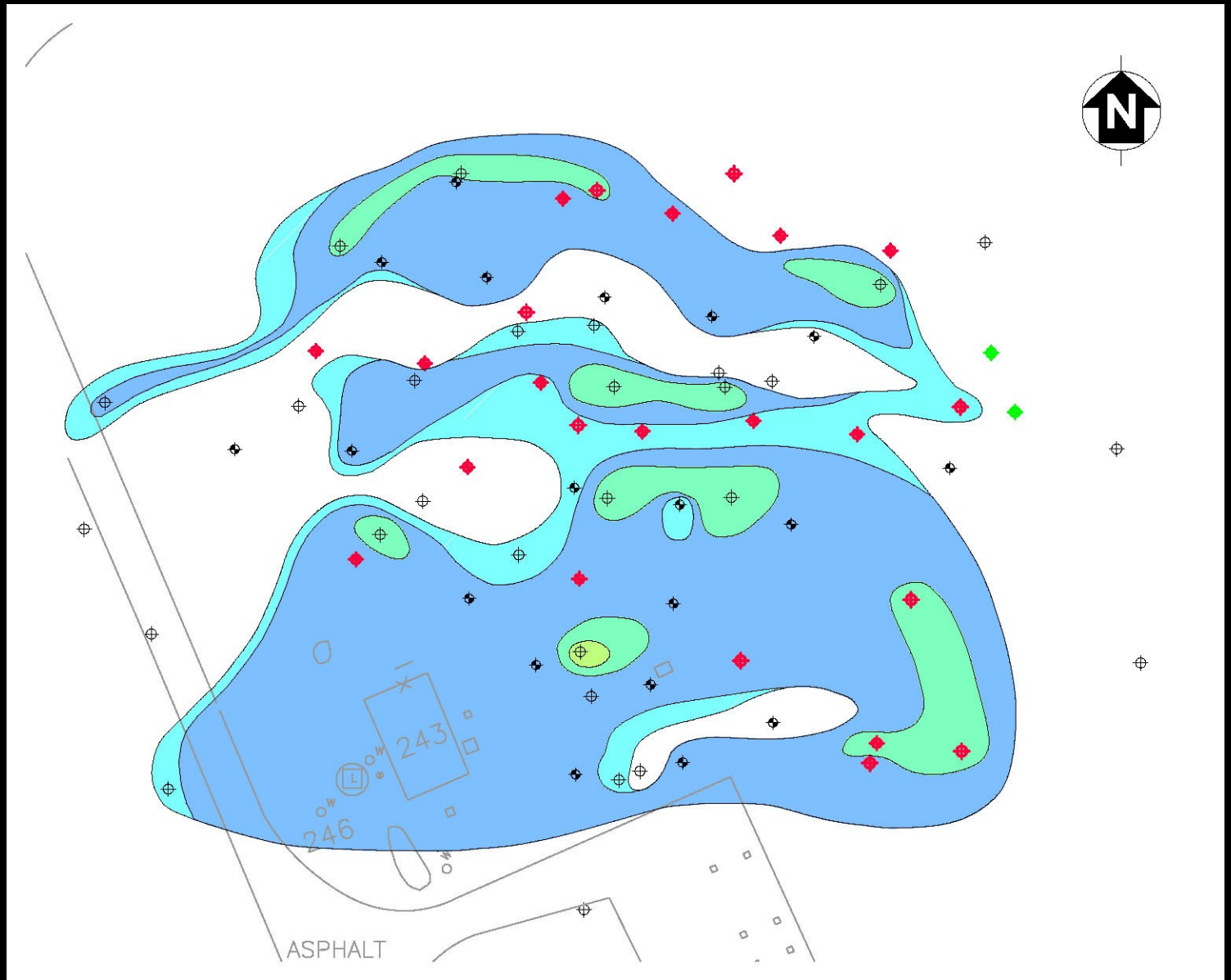
AFTER 4 MONTHS



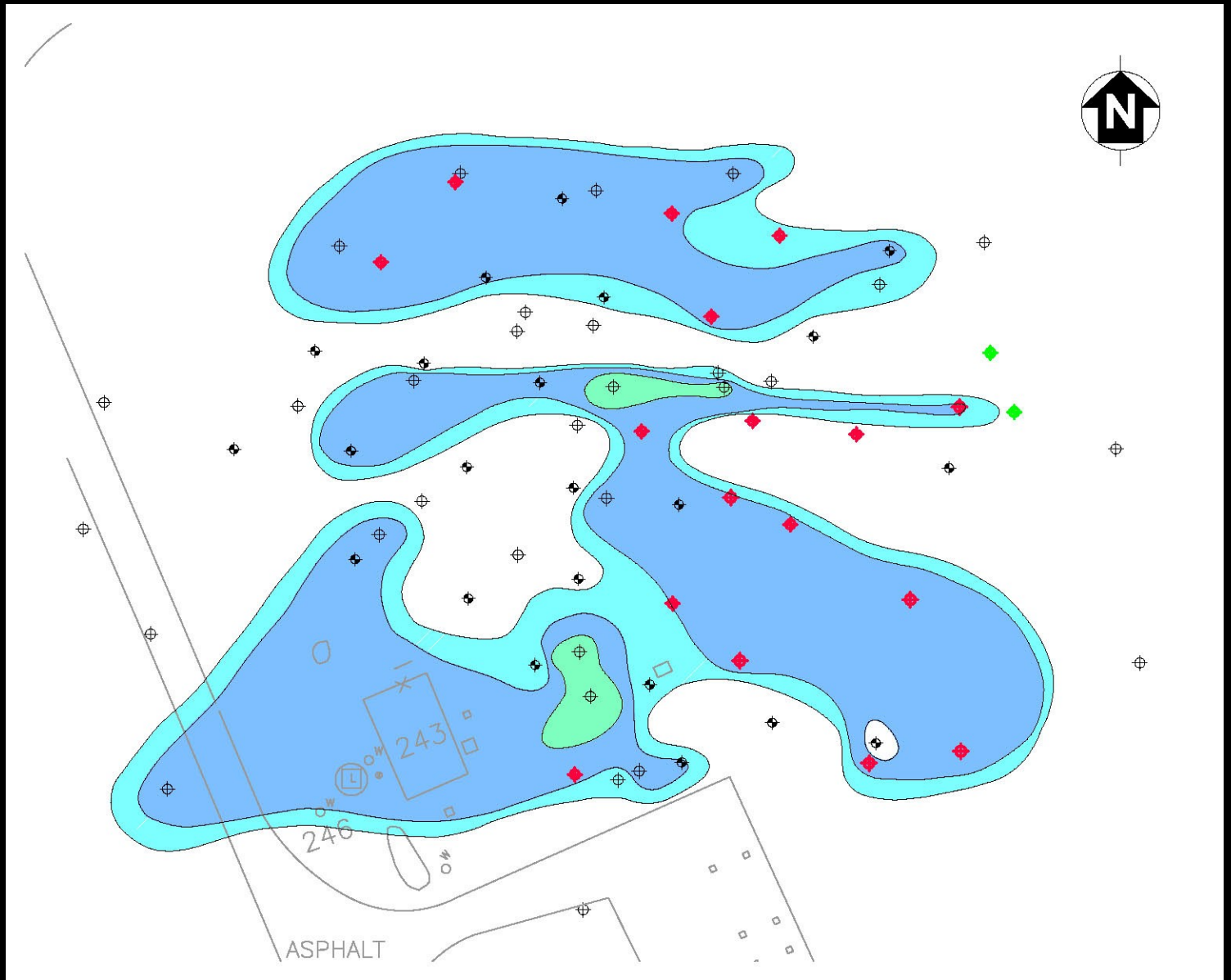
AFTER 5 MONTHS

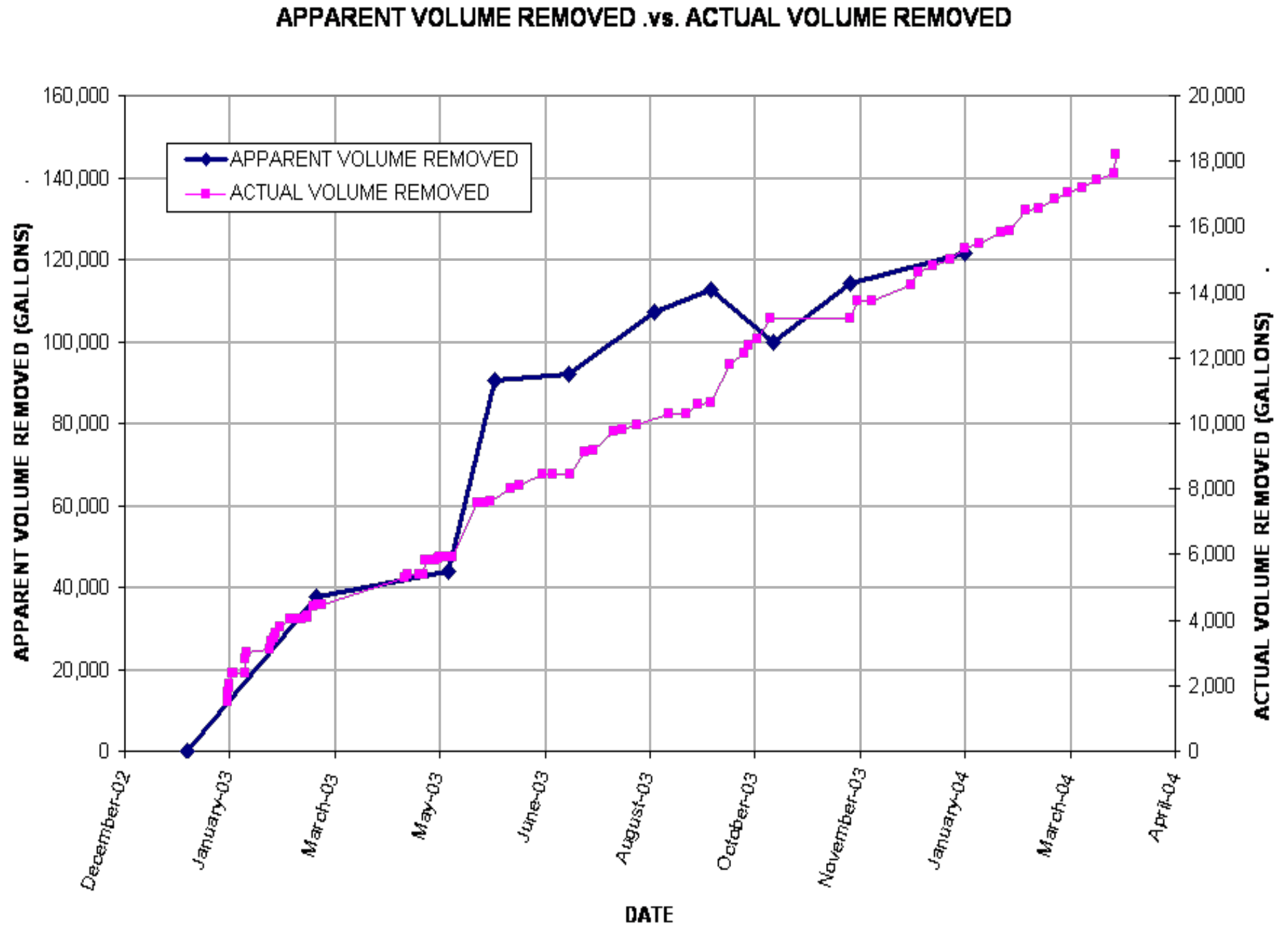


AFTER 8 MONTHS

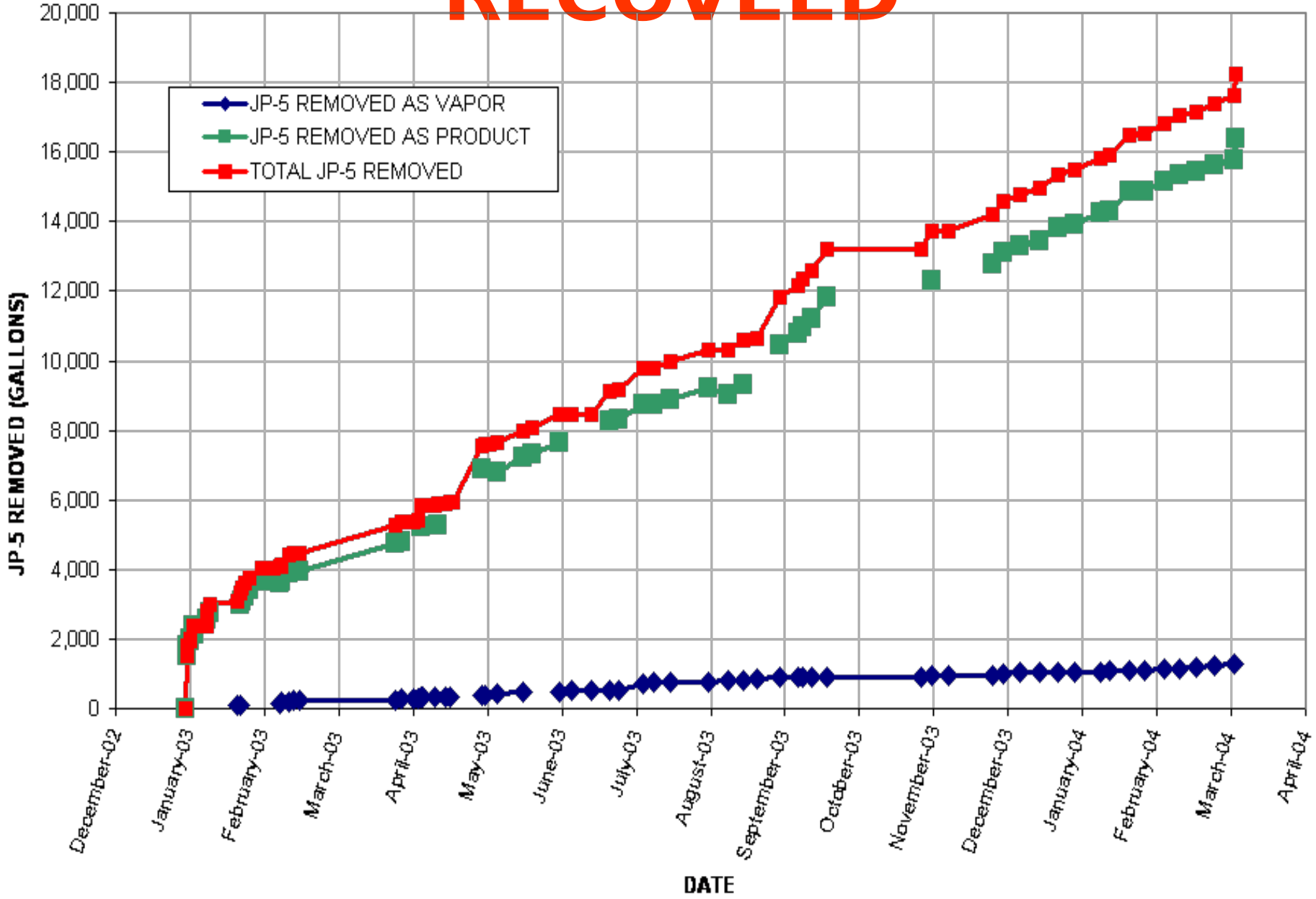


AFTER 11 MONTHS

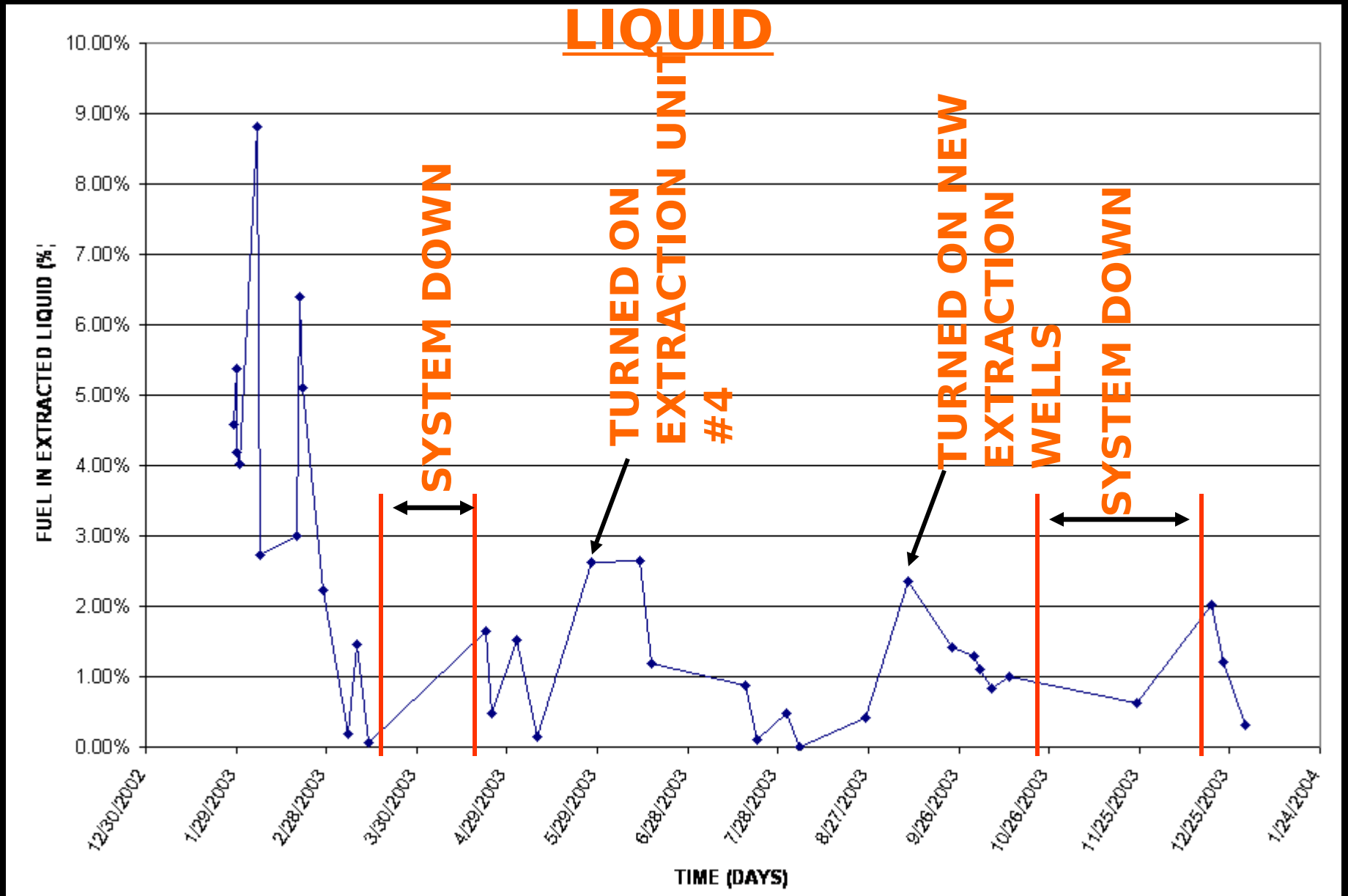



APPARENT VOLUME REMOVED .vs. ACTUAL VOLUME REMOVED
APPARENT VOLUME REMOVED
ACTUAL VOLUME REMOVED
APPARENT VOLUME REMOVED (GALLONS)
ACTUAL VOLUME REMOVED (GALLONS)
DATE
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
December-02
January-03
March-03
May-03
June-03
August-03
October-03
November-03
January-04
March-04
April-04

VOLUME OF JP-5 RECOVEED



PERCENTAGE OF FUEL IN EXTRACTED LIQUID



QUESTIONS?
NO SMOKING
CAUTION